INTERNATIONAL STANDARD

ISO 6846

Second edition
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Photography — Black-and-white continuous-tone papers — Determination of ISO speed and ISO range for printing

Photographie — Papiers noir et blanc pour images à tons continus — Détermination de la sensibilité ISO et de l'étendue ISO pour le tirage

Reference number
ISO 6846:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 6846 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 6846:1983), of which it constitutes a technical revision.

Annexes A, B, C and D of this International Standard are for information only.

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Introduction

This International Standard establishes a method for measuring those photographic characteristics of papers used for printing from negative images which will aid users to select the appropriate products for their applications. ISO speed and ISO range are two measurements considered important for this purpose.

Studies have shown that highly acceptable prints are generally obtained if the log exposure range (LER) of a photographic paper is equal to the effective density range of the negative.[1)] Therefore, ISO range, which is directly related to LER provides a useful criterion for grading papers. Some diversion from this criterion can be required to obtain optimum prints because of subject matter, individual preferences, and paper characteristics such as D_{max}, surface and curve shape.

Each manufacturer has established a unique system for grading of papers and designations which makes it extremely difficult for users to identify products which are comparable for printing characteristics. The ISO range number is introduced to reduce this source of confusion.

ISO range is not a measure of image contrast, but a useful guide for selecting the proper paper (or the proper filter for variable contrast paper) for a given effective negative density range, and for comparing products from various manufacturers. Print image contrast can be specified by three different types of objective measurements in relation to two specified points on the paper characteristic curve

a) difference in density between the two points (density range);

b) the slope of a straight line connecting the points (average gradient); and

c) the difference in log exposure for the two points (log exposure range).

Of the three, log exposure range is most closely associated with the concept of paper contrast grades (see annexes B and C).

The diffuse density range of a negative is not an accurate measure of the illuminance range at the printing plane when printers are employed that have specular type optical systems. Since conditions which satisfy the diffuse density criteria normally exist only in contact printing, the term "effective density range" has been introduced (see annex A).

It is the effective density range of the negative which should be matched with the log exposure range of the printing material in the usual projection printing mode for optimum tone reproduction.

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1) JONES, L.A. and NELSON, C.N. Control of Photographic Printing: Improvements in Technology and further Analysis of Results. *Journal of the Optical Society of America, 38* (11):1948.

The effective density range of a negative image can be calculated from the measured ISO diffuse transmission density range by applying the proper correction factors for specularity and flare to the values. Alternatively, the illuminance range can be measured in the printing plane with a suitable photometer (see annex A).

Most manufacturers have classified photographic papers by using a grade number ranging from 00 to 6. The larger the grade number, the greater is the contrast within a specific line of papers.

ISO range numbers will generally be lower as contrast increases. The concept of ISO range was adopted recognizing that users generally evaluate the density range of a negative (visually) in selecting the paper grade to use. If the density range is small, a paper with a small ISO range number should be used. It will take time to adapt to this new concept, but establishing an internationally accepted method of classifying papers in this manner will have significant long-term benefits for users.

It is not feasible to include provisions in this International Standard for the wide range of exposing conditions used in the trade. For this reason, the interpretation of the speed and range numbers obtained by following the procedures herein are possibly not directly applicable when products are exposed using sources other than a tungsten lamp operating at 2 856 K.

Since a particular paper is designed to provide optimum results in particular processes, this International Standard does not specify one single process. To do so would be considered unduly restrictive and could result in yielding ISO speed and ISO range numbers which were not typical of those obtained in processes specified by the manufacturer.

Photography — Black-and-white continuous-tone papers — Determination of ISO speed and ISO range for printing

1 Scope

This International Standard specifies the method for determining the ISO speed and ISO range of black-and-white photographic papers used to make positive reflection prints of continuous-tone subjects from black-and-white film negatives. It pertains to all conventional silver-halide contact and enlarging papers used for continuous-tone or pictorial photography. This includes papers with variable contrast. The papers may be processed in conventional chemicals and equipment, but also using special procedures such as those involving activators or heat for development.

This International Standard does not apply to:

a) non-silver papers;

b) high contrast silver papers, such as those used in the graphic arts, or other non-pictorial applications;

c) silver papers used to obtain a direct positive or reversal image.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5-3:1984, *Photography — Density measurements — Part 3: Spectral conditions.*

ISO 5-4:1983, *Photography — Density measurements — Part 4: Geometric conditions for reflection density.*

ISO 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications.*

ISO 6728:1983, *Photography — Camera lenses — Determination of ISO colour contribution index (ISO/CCI).*

ISO/CIE 10526:1991, *CIE standard colorimetric illuminants.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 exposure[2], H: The time integral of illuminance on the paper measured in lux seconds and designated by the symbol H. Exposure is often expressed in base ten logarithmic form.

3.2 speed: A quantitative measure of the response of the photographic material to radiant energy for the specified conditions of exposure, processing, and image measurement.

3.3 log exposure range, LER**:** The range of log exposure values normally used to produce a final print. It is the difference in log exposure values required to produce two specified densities on the paper.

3.4 minimum density, D_{min}: The minimum density value obtainable from an unexposed sample of the product following the process used in the ISO speed determination.

2) CIE 17.4 uses the term "luminous exposure".

4 Sampling and storage

In determining the ISO speed and ISO range of a product, it is important that the samples evaluated yield the average results obtained by users. Prior to evaluation, the samples shall be stored according to the manufacturer's recommendations for a length of time to simulate the average age at which the product is normally used. To assure that all components of variance are included in the sampling plan, it is recommended that procedures such as those outlined in ISO Standards Handbook 3 be used. Other suitable reference sources are given in the bibliography.

5 Test method

5.1 Principle

Samples are exposed and processed as specified below. Density measurements are obtained from the resultant image to produce a sensitometric curve from which measurements are taken and used to determine ISO speed and ISO range values.

5.2 Safelights

To eliminate the possibility of safelight illumination affecting the sensitometric results, all papers shall be handled in complete darkness until thoroughly fixed.

5.3 Exposure

5.3.1 Sample condition

During exposure, the samples shall be held at a temperature of 23 °C ± 2 °C and a relative humidity of (50 ± 5) % in accordance with ISO 554.

5.3.2 Type of sensitometer

The sensitometer shall be a non-intermittent, illuminance-scale type.

5.3.3 Radiant energy quality

The spectral power distribution of the illuminant shall be that of a black body radiator operated at a temperature of 2 856 K (CIE standard illuminant A as described in ISO/CIE 10526) modified by the ISO standard camera lens as described in ISO 6728.

If this International Standard is followed in all respects except that the light from the source is modified by a filter, as in the case of variable contrast papers, this International Standard may be complied with by indicating that the speed and range quoted apply to the specific combination of paper and filter used.

5.3.4 Modulation

The total range of spectral diffuse transmission density with respect to the paper plane of each area of the light modulation throughout the wavelength interval from 400 nm to 700 nm shall not exceed 5 % of the average density, or 0,03 density units, whichever is greater. In the interval from 360 nm to 400 nm, 10 % of this same average density or 0,06 density units, whichever is greater, is acceptable.

If stepped increment modulation is used, the increment of $\log_{10}H$ shall not be greater than 0,15. The width and length of a single step shall be adequate to obtain a uniform density area (devoid of adjacency effects) within the reading aperture specified for densitometry (see 5.5).

If continuous variable modulation is used, the change in $\log_{10}H$ with distance along the test strip shall be uniform and shall be not greater than 0,04 per millimetre.

5.3.5 Exposure time

The exposure time shall be between 0,1 s and 10 s corresponding to the usage practice for the particular paper tested.

Since the speed of paper is dependent on the exposure time because of reciprocity law failure effects, the exposure time used for determining the ISO speed and ISO range should be specified in the use instructions.

An area of the paper shall be left unexposed in order to produce the minimum density possible.

5.4 Processing

5.4.1 Conditioning of samples

In the time interval between exposure and processing, the samples shall be kept at 23 °C ± 2 °C and a relative humidity of (50 ± 5) %. The processing shall be completed between 1 min and 2 h after exposure.

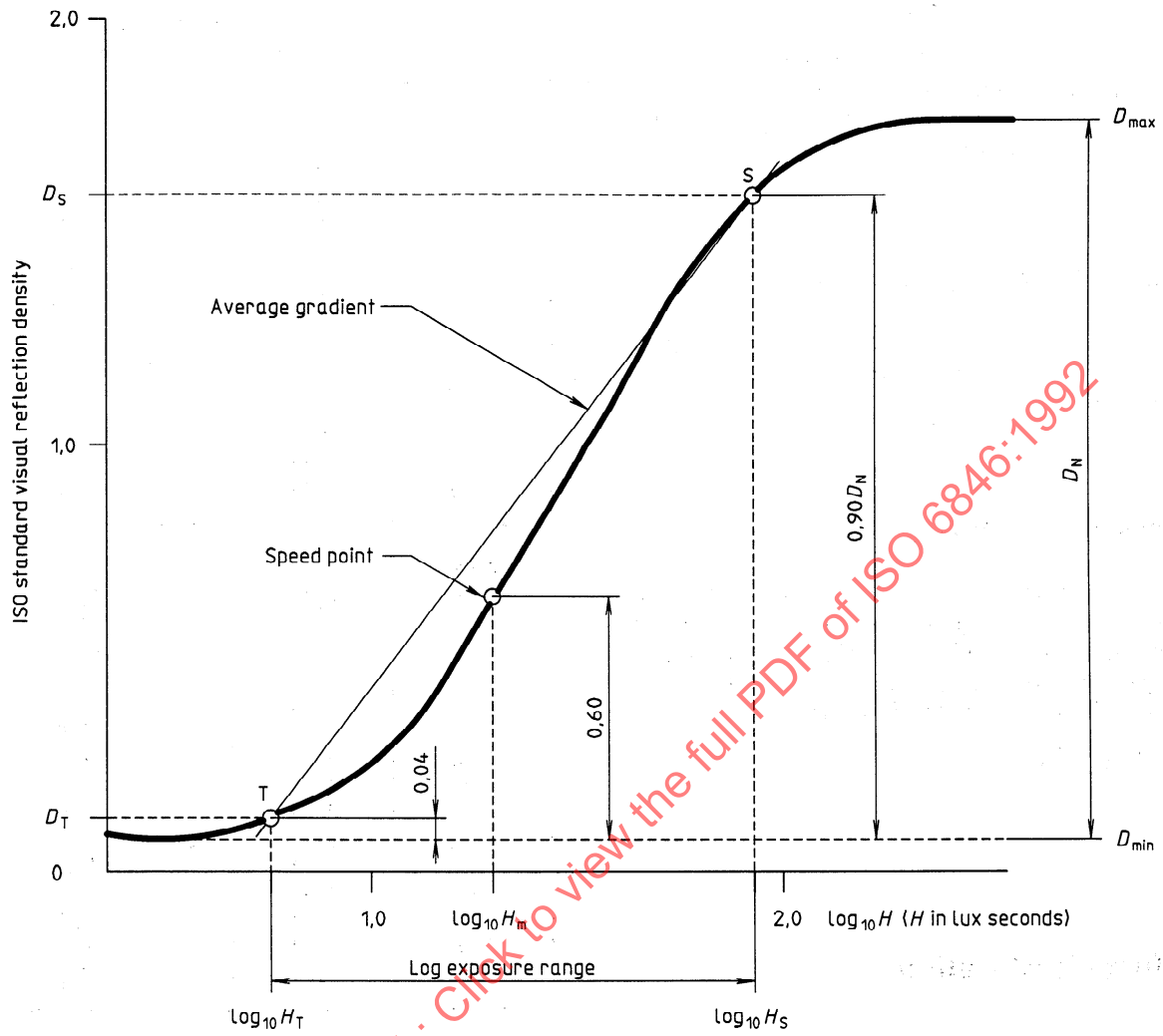

Figure 1 — Sensitometric curve

5.4.2 Processing specifications

No processing specifications are described in this International Standard, in recognition of the wide range of chemicals and equipment used. ISO speed and ISO range provided by paper manufacturers generally apply to the paper when it is processed in accordance with their recommendations to produce the photographic characteristics specified for the process. Process information shall be available from the paper manufacturers or others who quote ISO speed and ISO range. This information shall specify the chemicals, times, temperature, agitation, equipment and procedure used for each of the processing steps, and any additional information (such as drying conditions that effect gloss) required to obtain the sensitometric results described. The values for speed and range obtained using various processing procedures can differ significantly. Although different speeds or ranges for a particular paper can be achieved by varying the processes, the user should be aware that other sensitometric and physical changes can also accompany the speed and range changes.

5.5 Densitometry

The ISO standard visual reflection density of the processed paper images shall be measured using a densitometer complying with the geometric requirements specified in ISO 5-4 and the spectral requirements specified in ISO 5-3. Readings shall only be made on uniform areas of the exposures.

5.6 Evaluation

5.6.1 Sensitometric curve

The ISO standard visual reflection density values are plotted against the logarithm to the base 10 of the corresponding exposures, H, expressed in lux seconds to obtain a sensitometric curve similar to that illustrated in figure 1.

5.6.2 Minimum density, D_{min}

The minimum density shall be determined from unexposed samples of the same paper processed simultaneously with the sample exposed for determining the sensitometric curve.

5.6.3 Maximum density, D_{max}

The value D_{max} represents the density of the sample whose density does not systematically increase with increasing exposure.

5.6.4 Maximum net density, D_N

The value D_N represents the maximum reflection density of the sample, adjusted for D_{min}. This value is called maximum net density and relates to the maximum image contrast achievable on the paper (see figure 1). It is derived from the formula:

$$D_N = D_{max} - D_{min}$$

6 Product classification

6.1 Speed calculation

Raw speed values, S, are derived from the formula:

$$S = \frac{1\,000}{H_m}$$

where

H_m is the exposure, in lux seconds, required to produce a density of 0,60 above D_{min}.

6.1.1 ISO speed

ISO speed can be obtained directly from $\log_{10}H_m$ using table 1 which effectively rounds the raw speed value to one of the designated ISO speeds in the ISO speed scale. First determine $\log_{10}H_m$ to two decimal places from figure 1. The appropriate $\log_{10}H_m$ range is then selected from the two columns on the left side of table 1 and the corresponding ISO speed is found in the right hand column of table 1.

Table 1 — ISO speed

$\log_{10}H_m$		ISO speed
from	to	
– 0,55	– 0,46	P3200
– 0,45	– 0,36	P2500
– 0,35	– 0,26	P2000
– 0,25	– 0,16	P1600
– 0,15	– 0,06	P1250
– 0,05	0,04	P1000
0,05	0,14	P800
0,15	0,24	P640
0,25	0,34	P500
0,35	0,44	P400
0,45	0,54	P320
0,55	0,64	P250
0,65	0,74	P200
0,75	0,84	P160
0,85	0,94	P125
0,95	1,04	P100
1,05	1,14	P80
1,15	1,24	P64
1,25	1,34	P50
1,35	1,44	P40
1,45	1,54	P32
1,55	1,64	P25
1,65	1,74	P20
1,75	1,84	P16
1,85	1,94	P12

6.1.2 ISO speed of a product

The ISO speed of a product (as distinguished from that of a specific sample) shall be based on the arithmetic mean of the base ten logarithms of exposures, $\log_{10}H_m$, on a statistical sampling of the product. The samples shall be chosen such that all the components of variance are included and shall be stored and tested as specified above (see clauses 4 and 5). The ISO speed of a product with proper rounding is then determined from the average value of $\log_{10}H_m$ by use of table 1.

Since ISO speed is dependent on the processing conditions, these should be indicated when quoting ISO speed values.

6.1.3 Accuracy

The calibration of the equipment and processes involved in determining ISO speed shall be adequate to ensure the absolute value of the error in $\log_{10}H_m$ is less than 0,05.

6.2 Range calculation

Raw range values, R, are derived from the formula:

$$R = 100(\log_{10}H_S - \log_{10}H_T)$$

where

H_S is the exposure required to produce a density which is 0,90 D_N, and

H_T is the exposure required to produce a density of 0,04 above D_{min}.

Points S and T generally correspond to the largest and smallest exposures the paper would receive through an average negative in producing a good print. $(\log_{10}H_S - \log_{10}H_T)$ is called log exposure range (LER) (see annex B).

6.2.1 ISO range

ISO range can be obtained directly from $(\log_{10}H_S - \log_{10}H_T)$ using table 2 which effectively rounds the raw range value to one of the designated ISO range values in the ISO range scale. First determine $(\log_{10}H_S - \log_{10}H_T)$ to two decimal places from figure 1. The appropriate $(\log_{10}H_S - \log_{10}H_T)$ range is then selected from the two columns on the left side of table 2 and the corresponding ISO range is found in the right hand column of table 2.

6.2.2 ISO range of a product

The ISO range of a product (as distinguished from that of a specific sample) shall be based on the arithmetic mean of the log exposure ranges determined from a statistical sampling of the product. The samples shall be chosen such that all the components of variance are included, and shall be stored and tested as specified above (see clauses 4 and 5). The ISO range of a product with proper rounding is then determined from the average value of LER using table 2.

6.2.3 Accuracy

The calibration of the equipment and processes involved in determining ISO range shall be adequate to ensure the absolute value of the error in LER is less than 0,01 or 3 % whichever is greater.

7 Product marking and labelling

7.1 ISO speed

Speed of a product determined by the method described in this International Standard and expressed on the scale of table 1, shall be designated ISO speed and denoted in the form of "ISO P100", or "ISO paper speed P100".

7.2 ISO range

Range of a product determined by the method described in this International Standard and expressed on the scale of table 2, shall be designated ISO range and denoted in the form of "ISO R140", or "ISO range 140".

7.3 General

Since the ISO speed and ISO range are not only dependent on the paper product, but also the process used to develop the image, the processing specification should be given whenever possible when quoting the values. An abbreviated form may be used, e.g. "ISO P100 (developer D-72)".

Table 2 — ISO range

$\log_{10}H_S - \log_{10}H_T$		ISO range
from	to	
0,35	0,44	R40
0,45	0,54	R50
0,55	0,64	R60
0,65	0,74	R70
0,75	0,84	R80
0,85	0,94	R90
0,95	1,04	R100
1,05	1,14	R110
1,15	1,24	R120
1,25	1,34	R130
1,35	1,44	R140
1,45	1,54	R150
1,55	1,64	R160
1,65	1,74	R170
1,75	1,84	R180
1,85	1,94	R190

Annex A
(informative)

Relationship between the paper range, R, and the effective density range of the negative

The log exposure range of a photographic paper provides a useful, but not a perfect, criterion for grading papers. It is useful because a satisfactory print is normally obtained when the log exposure range of a paper is matched to the effective density range of the negative image, provided that the scene and the scene lighting are normal. It is not a perfect criterion because papers with similar log exposure ranges will give prints that differ considerably in appearance if the shapes of the paper sensitometric curves are different. Moreover, a negative which prints well on a glossy paper (high D_{max}) will print equally well on a matt paper coated with the same emulsion (low D_{max}) even though their log exposure ranges will not be the same.

ISO range, which is determined directly from the log exposure range, is therefore a useful guide for selecting a paper for a negative of known image density range. The ISO range should match 100 times the effective density range of the negative image for a selected paper. For medium D_{max} papers, an exact match generally works best. For low D_{max} papers, the LER should be slightly less than the negative density range in most cases and conversely for high D_{max} papers. This means that to obtain the best prints from a single negative using two papers which differ in D_{max}, it is necessary in most cases for the lower D_{max} paper to have a smaller LER.

When a negative is contact-printed, its effective image density range equals its diffuse density range as measured by a properly calibrated transmission densitometer (see ISO 5). When an enlarger is employed, the effective negative density range will be greater because of the scattering characteristic (Q-factor[3]) of the negative film. (Stray light typically reduces the density range by 5 % to 10 %). A direct determination of the effective density range of the negative can be made with a photometer by measuring the maximum and minimum illuminance of the projected sharp image on the enlarger easel and finding the difference of the logarithm of the illuminances.

It should also be remembered that optimum print quality depends on aesthetic factors which can indicate the use of a paper whose log exposure range differs considerably from the effective density range of the negative. Thus, the use of the ISO range/effective density range relationship is only approximate, as a starting point for critical work. The paper range required should be determined for each printer/enlarger, developer and paper surface combination.

3) The Callier Q-factor is the ratio of specular density to the diffuse density of a specimen.

Annex B
(informative)

Relationship between log exposure range and contrast

The negative acts as a modulator, the density range of which controls the exposure range the paper receives. The two exposures used in this International Standard to determine the log exposure range generally correspond to the largest and smallest exposures the paper receives when negatives are printed properly. In turn, resultant densities correspond to the shadow and highlight areas of the original subject photographed. It follows that if the print is to reflect density gradients recorded in the negative, these densities should modulate the exposure to the paper where a paper gradient exists (that is, over the log exposure range (LER). It is, therefore, important that the LER of the paper matches the density range of the negative. In other words, the paper selected for printing should have an ISO range equal to 100 times the effective density range of the negative.

The impression of image contrast in a final print is influenced by many factors such as the lighting of the original subject, characteristics of the negative and print materials, print viewing conditions, etc. Papers intended for printing negatives with the same density range can produce images which appear quite different in contrast because of variations in surface, maximum density, and curve shape.

A contrast measurement from the sensitometric curve of the paper is sometimes useful in selecting a product to provide a desired tonal gradient in a print. An average gradient measurement is suggested for this purpose, which is the slope of the line drawn between points T and S shown in figure 1:

$$\overline{G} = \frac{D_S - D_T}{\log_{10} H_S - \log_{10} H_T}$$

Annex C
(informative)

Relationship between log exposure range and average gradient

Even though the log exposure range and ISO range used in this International Standard are the best measures of paper contrast for the purpose of selecting the best grade of paper for a given negative, they do not take into account differences in print density ranges attributable to differences in paper sheen. Average gradient is a measure of paper contrast that includes both log exposure range and the range of densities the paper is capable of producing and therefore is a useful measurement for comparing products. When the same basic print emulsion is used for both dull surface and glossy surface papers, the glossy paper will have a higher average gradient and also a larger log exposure range as a result of the larger maximum density. Even though the two papers have different log exposure ranges, they will both be the best contrast grade for a negative that is matched to either paper.